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# THE OBSERVATIONS OF THE FINNISH RIVER ICE RESEARCH PROJECT

Mikko Huokuna (ed.)

V E S I - J A Y M P Ä R I S T Ö H A L L I T U K S E N
M O N I S T E S A R J A

Nro 300 E

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Abstract
Within the years 1985-1989 was developed a numerical one-dimensional river flow model for winter conditions. The field observations needed for development and calibration of the model have been carried out in four river stretches. There is in the publication a list of the contents of the different files and the description of the format how the data is arranged.

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## Preface

To enable the development and calibration of a numerical River ice model a four–year project was started in 1985 by the Association of Finnish Power Stations, some hydroelectric power companies and the National Board of Waters. The Consulting Engineers Reiter Ltd. got the task to develop numerical river ice model. The river ice observations wich were carried out at four river reches were important part of the project. Before the project ended 1989, the National Board of Waters and Environment and the Association of the Finnish Power Stations desided to arrange the data so that it could be easyily reused.

Most of the data collected during the project is digitized and stored into files. In the chapters 5 – 8 there is a list of the contents of the different files and the description of the format how the data is arranged. The questions about the observations can be send to the National Board of Waters and Environment. Adress:

The National Board of Waters and Environment

Urho Kekkosenk. 4–6 E
PL 250
00101 Helsinki
Finland

I want to express my gratitiude to all those who were involved to carry out the observation data. Especially I want to thank the leader of the River Ice Research Project, Mr. Markku Maunula from the National Board of Watres and Environment. It was a pleasure to work in this project.

Helsinki April 14. 1991

Mikko Huokuna
Consulting Engineers Reiter Ltd.

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# 1. INTRODUCTION

To enable the development and calibration of a numerical River ice model a four–year project was started in 1985 by the Association of Finnish Power Stations, some hydroelectric power companies and the National Board of Waters. The project was also funded by the Ministry for Trade and Industry and some hydroelectric power companies. The numerical river ice model was developed by Consulting Engineers Reiter Ltd. The model which is called JJT–model and the results of the Finnish river ice research project are described in the final report of the project (In Finnish). More information about the the project and the numerical model in English are given in the papers Huokuna (1988) ja Huokuna (1990).

Soon at the beginning of the project it became clear that lots of observations were needed for development, calibration and verification of the numerical River ice model. The observations were carried out during winters 1985–1986, 1986–1987 and 1987–1988 in four different River reaches. Some observations were also made during winter 1988–1989. The most important parameters gathered were discharge, stage, water temperature, ice cover appearance, growth and melting of ice cover, ice break up conditions and weather conditions (air temperature, wind velocity and direction, relative humidity and cloudiness). Also observations about the strentgh of ice cover and about anchor ice were made. Observation reaches were chosen so that there was a hydropower plant located at the upstream end of every reach. Discharges and water temperature values could be observed at a short time intervals at the hydropower plants. Some data (cross–sectional data and observations about open water discharges and stages) were available soon when the project was started.

The observations were divided into the observations of freeze–up period, winter period and break–up period. During freeze–up periods attention was paid to the observations of ice coverage, water temperature and stages. During winter periods the growth and decrease of ice cover, snow ice, frazil and snow were the most important parameters to measure. During break–up periods the amount of stage measurements, water temperature measurements and ice coverage (open water areas) measurements was increased. Weather observations were gathered from the official observation stations, which located near the study reaches.

During every winter about 800 hours of work was needed for observations at every study reach. Observation program was prepared separately for each study reach to organise and guide the observation work. These observation programs were revised during the project according to experiences.

Most of the numerical data collected during the project is digitized and stored in a data bank. The data from the data bank is available from the National Board of Waters and the Environment. The original data including observation forms, maps, drawings and photographs are stored by the organisations that carried out the observations: the Kymi district office of The National Board of Waters and The Environment (Kymijoki), the Kokkola district office of The National Board of Waters and The Environment (Kalajoki) , Oulujoki Ltd (Oulujoki) and Kemijoki Ltd (Kitinen).

# 2. THE PRESENTATION OF THE STUDY REACHES

## 2.1 General

Stretches for investigation were chosen from the courses of the Rivers Kymijoki, Kalajoki, Oulujoki and Kitinen, the latter being a tributary of the River Kymijoki (Figure 1). The choice of the Rivers took into account different ice conditions and climatological conditions, the degree of regulation of the watercourse and the problems associated with its utilization during the winter season.

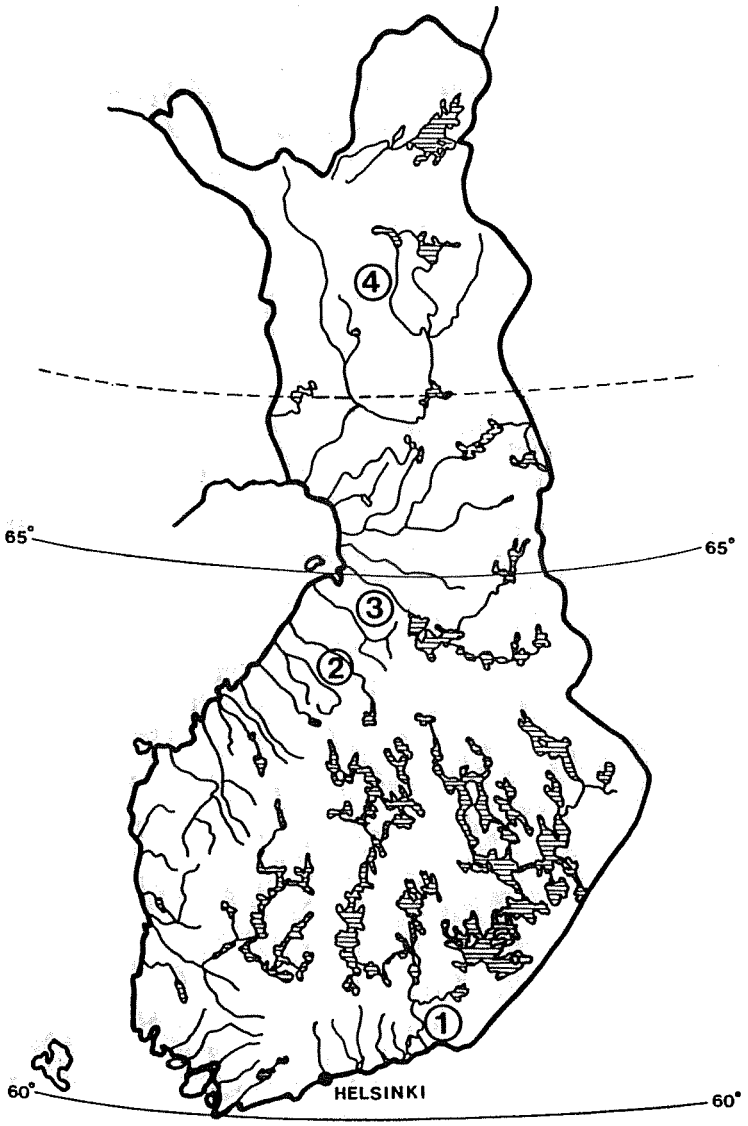


Figure 1. The location of study reaches. 1 Kymijoki, 2 Kalajoki, 3 Oulujoki ja 4 Kitinen.

## 2.2 Kymijoki

The drainage basin of the River Kymijoki, the middlemost of the three main watercourses of the Finnish Lake District, has a surface area of 37 235 km², or 11 % of the area of the whole Finland. The central lake of the watercourse is the lake Päijänne ( 1 100 km²), which has been regulated since 1964. Water descends southwards from the lake Päijänne via the River Kymijoki into the Gulf of Finland. The percentage of the total area of Kymijoki watershed is as high as 19 %. Thirteen hydroelectric power stations are located along the River Kymijoki, with a combined power output of 200 MW and a total annual energy production of 1200 GWh/a.

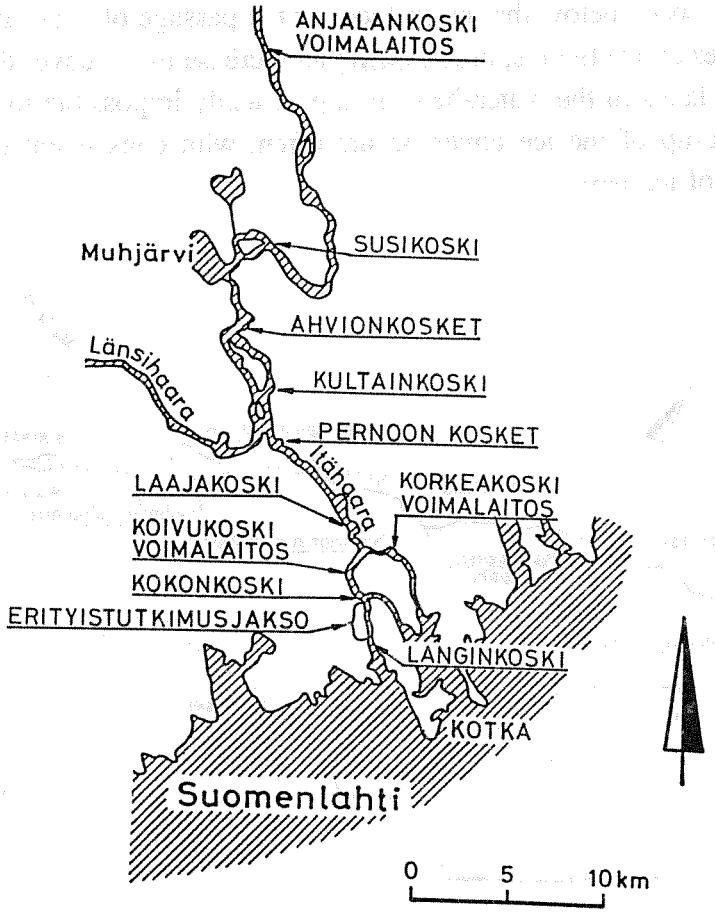


Figure 2. The study reach of the River Kymijoki.

The part of the River chosen for investigation is an approximately 40 km stretch between Anjala and the Gulf of Finland (Figure 2). This stretch includes several natural rapids which stay open during winter. Anchor ice and frazil make it difficult to utilize the River Kymijoki during winter season.

## 2.3 Kalajoki

The area of the drainage basin of the River Kalajoki is 4 200 km$^2$ . The River is located in Ostrobothnia and it flows into theGulf of Bothnia. The percentage of lakes of the drainage basin is only 2,5 %. Therefore the difference between maximum and minimum flow is very high. There are four hydroelectric power plants located along the River and their combined power production is about 12 MW and the mean annual energy production is 31 GWh/a.

A 60 km stretch of the River between Pidisjärvi and the Gulf of Bothnia was chosen for this investigation (Figure 3). Particularly in the unconstructed lower reaches of the River there are several locations at which ice problems regularly occur. At these points, the water is so shallow that there remains insufficient space below the ice surface for the passage of water in winter. Consequently, water often rises above the ice, thus causing an increase in ice cover thickness. Because there are only a few lakes in the watershed, it is practically impossible to decrease spring flow rates. Raw break–up of the ice cover occurs often, with consequent extensive damage due to the formation of ice jams.

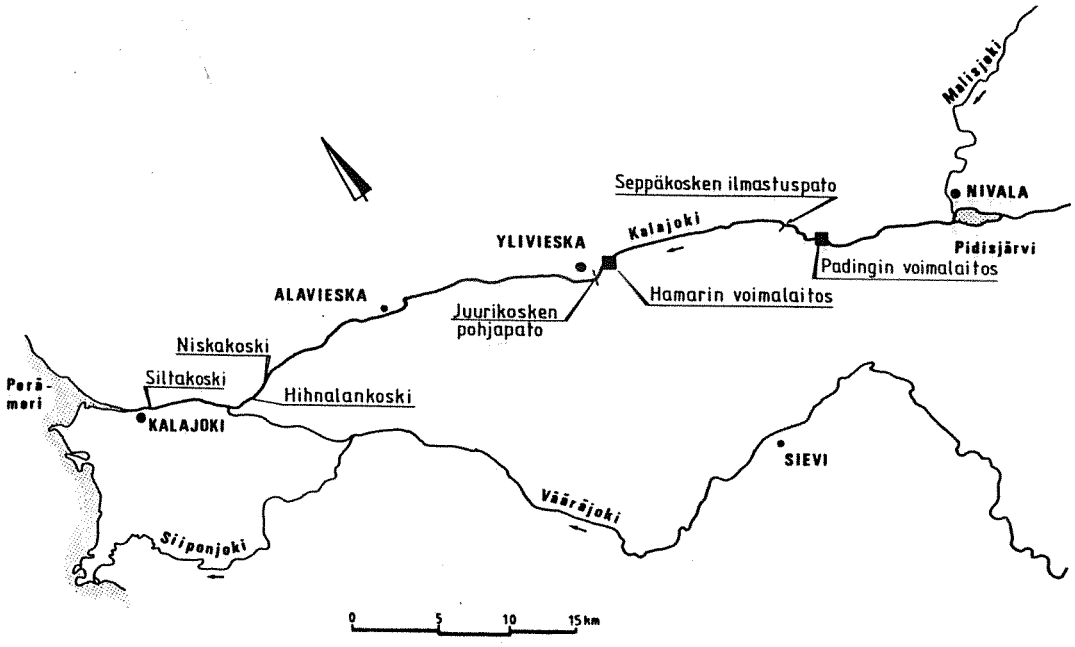


Figure 3. The drainage basin of the River Kalajoki. Study reach is located downstream of the lake Pidisjärvi.

## 2.4 Oulujoki

The drainage area of the River Oulujoki is the sixth largest in Finland, with a surface area of 22 900 km$^2$. The percentage of lakes of the whole drainage basin is 11,4 %, the main lake being

the lake Oulujärvi (928 km²). Flow conditions in the watercourse are affected by the regulation of the lake Oulujärvi and by the short–term regulation of the 18 power plants. The total combined power output of the power plants along the the River Oulujoki is 560 MW and their mean annual energy production is 2 500 GWh/a. A stretch of about 20 km between Montta and Merikoski (Figure 4) was chosen for this investigation. Considerable flood damages have been caused in the vicinity by frazil ice dams, and reduction in the falling height of the water has resulted significant losses in energy production.

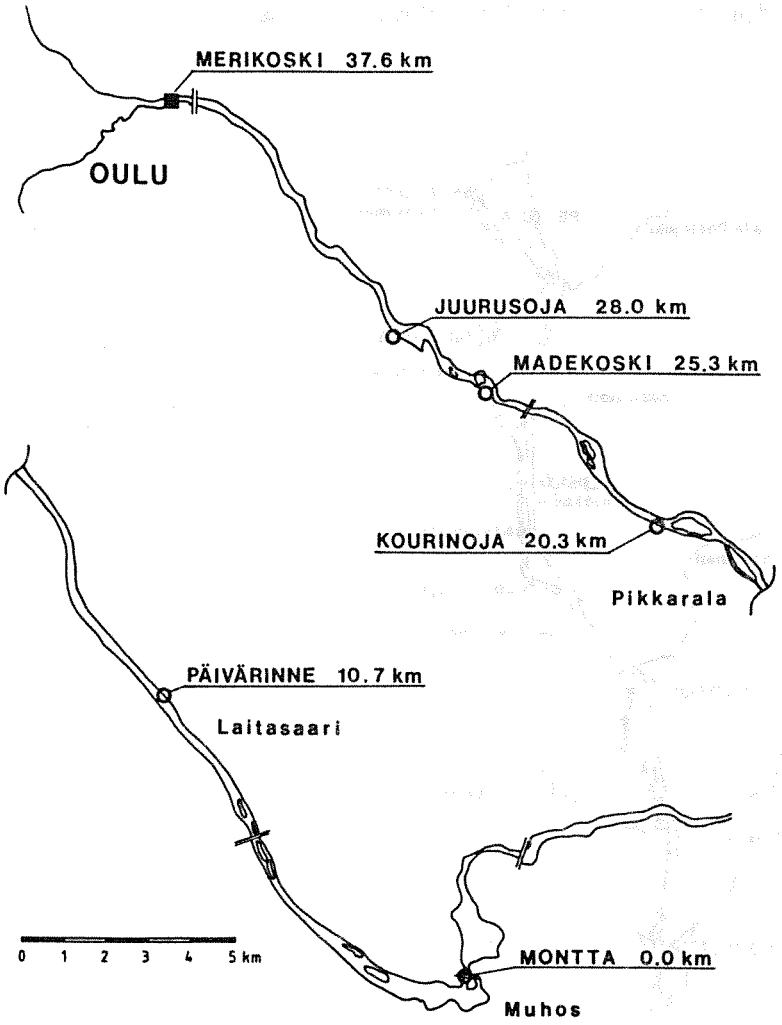


Figure 4. The study reach of the River Oulujoki.

## 2.5. Kitinen

The surface area of the River Kemijoki drainage basin is 50 910 km² and its lake percentage is 4,5 %. The basin area of Kitinen, a tributary of the River Kemijoki is 7 515 km². The major lake of the River Kemijoki is lake Kemijärvi (348 km²), which is regulated for the purpose of

hydroelectric power production. Reservoirs have been constructed in the headwaters of the River at Porttipahta and Lokka. Their combined surface area is 631 km$^2$. The combined power output of the 14 power stations along the River Kemijoki is 850 MW and their annual energy production is 4 000 GWh/a. For the River Kitinen the values are 56 MW and 166 GWh/a respectively.

A 50 km stretch between Vajukoski and Tähtelä were chosen to study reach (Figure 5). With the exception of flood periods, the flow rate of the River Kitinen is governed by the discharge from the reservoirs, because the drainage basin of the River is very small. Another special feature of the River is that the water discharged from the reservoirs is rather warm, with the result that the River remains open for about the first 20 km through the winter.

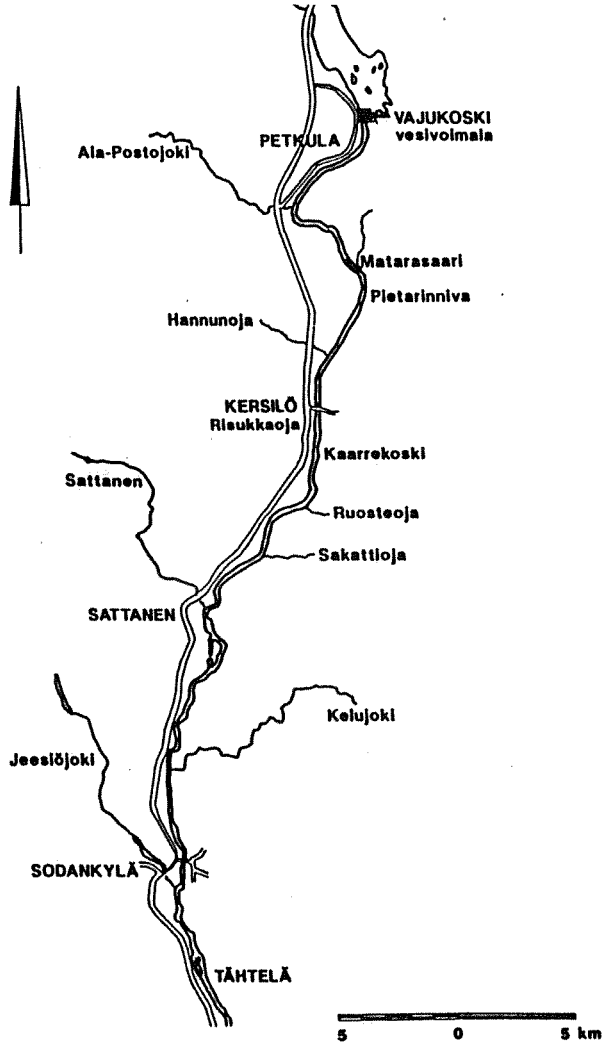


Figure 5. The study reach of the River Kitinen

# 3. OBSERVATION SITES AND METHODS

## 3.1 General

When we are studying river ice processes and problems caused by river ice we have to observe at least weather conditions, water temperature, ice cover appearance, ice cover thickness (including snow ice frazil and snow cover) and hydrological and hydraulic conditions. Also many other observations such as those of anchor ice, or measuring of mechanical features of ice cover may be done. The extensive amount of data collected during the Finnish River Ice Project can be explained by the varied range of data which is needed for analysis of river ice conditions.

Part of the data, for example part of the discharge and stage data and metorological data, was collected during the normal hydrological and meteorological data collection. However a large quantity of data was collected mainly for the purposes of the river ice research project (most of the stage and discharge data and the observations of ice cover thickness). Aerial photographs were used to analyse appearance of ice cover and water temperature observations. Also some observations were made about anchor ice and ice cover strength. An impulse radar was used extensively to study the amount of frazil under the ice cover.

In Table 1. the amount of automatical and manual stage, discharge and water temperature observation stations used in the Finnish River Ice Research Project are presented.

Table 1. The amount of automatical and manual stage, discharge and water temperature observation stations.

| The name of the river and the length of the study reach | Discharge at hydro power station | Water level at hydro power sation | Water level automatical cauges | Water level manually observed gauges | Water temperature automatical gauges | Water temperature manually observed |
|---|---|---|---|---|---|---|
| Kymijoki 40 km | 2 | 2 | 5 | 8 | 1 | 5 |
| Kalajoki 75 km | 2 | 3 | 4 | 31 | 1 | 5 |
| Oulujoki 37 km | 2 | 2 | 4 | 1 | 2 | 2 |
| Kitinen 47 km | 1 | 1 | 1 | 12 | 1 | 4 |

### 3.2 Meteorological data

Meteorological data was collected at the official weather stations located near the four study reaches. The observation stations were Sodankylä Tähtelä (Kitinen), Oulunsalo Airport (Oulujoki), Nivala kk (Kalajoki) and Utti (Kymijoki). The time interval for the observation of air temperature, wind speed and direction, cloudiness and relative humidity was three hours. Cumulative precipitation was measured every six hours.

### 3.3 Discharge data

Discharge data was measured at hydro power stations by using the measured power production. Values were stored using hourly mean values during freeze–up time and break–up time and by using daily mean values during winter time. At Oulujoki and Kymijoki the amount of lateral inflow is not important. The lateral inflow values for Kitinen were estimated by Kemijoki Ltd. and for Kymijoki they were estimated by the Kymi District Office of the Board of Waters and the Environment.

### 3.4 Stage data

Automatical storing of water levels took place at the hydropower plants and at the automatical gauges. Stage was measured automatically in six locations at Kymijoki, in eigth locations at Kalajoki, in six locations at Oulujoki and in three locations at Kitinen. Some of these gauges were set up only for the River Ice Research Project, but most of them were used also for other purposes. Values were stored hourly during freeze–up time and break up time and daily during winter time.

Because of long study reaches all the stage data that was needed could not be gathered by automatical gauges. Part of the manual gauges were official gauges and they were read once a day during the whole project. Part of the manual gauges were set up for the project and they were measured once a week during freeze–up and break–up and once a month during winter. There were eigth manual gauges at Kymijoki, 31 at Kalajoki, one at Oulujoki and 12 at Kitinen. All the data gathered from manual gauges was stored into the data bank.

### 3.5 Water temperature data

Water temperature data was collected automatically at the hydropower plants and manually along the study reaches.

There were altogether six automatical water temperature measuring stations for the four study reaches. Upstream water temperature was measured automatically for all the reaches. During freeze–up and break–up water temperature values were stored at the interval of one hour.

During the project Finnish Institute for Marine Research developed a new portable thermometer for manual observation of water temperature. The absolute accuracy of the meter is 0,03 °C and observations can be made very quickly, which is important when observers are working under hard winter conditions. During freeze–up and break–up water temperature was measured

manually about twice a week at 16 locations at the study reaches. All the manually collected water temperature data is stored into the data bank.

### 3.6 Thickness of black ice, snow ice , frazil and snow cover

Thickness of black ice, snow ice and frazil was measured manually through drilled holes. There were about 10 lines across each study reach where about 5 holes were drilled and the thickness of black ice, frazil and snow ice were measured. Thickness of snow cover was measured beside the drilled holes. The data was collected from two to four times a month during December, March and April and once a month during January and February. Observation form 2 (appendix 2) was used to collect this data which is stored in the data bank.

The thickness of frazil accumulations was measured also by a radar which is a modified version of the Subrurface Interface Radar (SIR) manufactured by the Geophysical Survey Systems Inc. A new signal proprocessor and a video display have been developed in the Radio Laboratorio of the Helsinki University of Technology. In Figure 6 there is an example of the output of the radar. More information about radar is given in a paper by Martti Toikka (Toikka 1987).

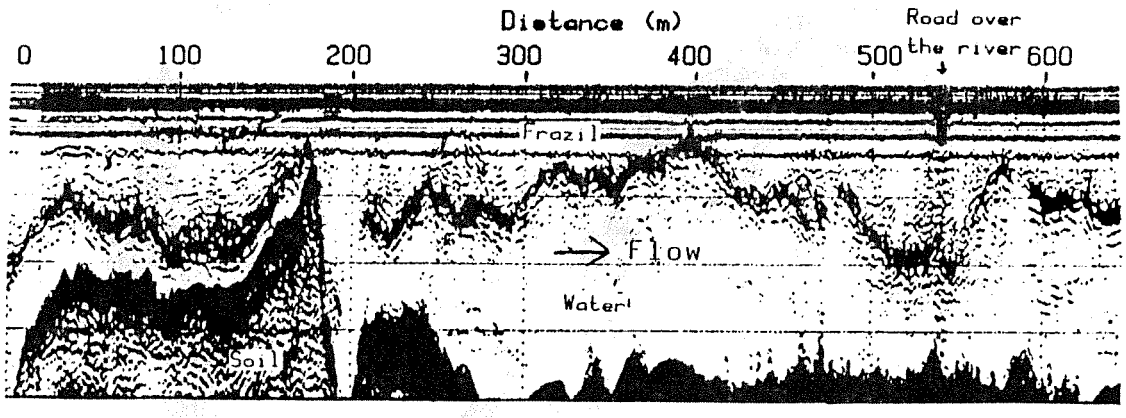


Figure 6. An example of the output of the impulse radar used to measure thickness of frazil accumulations under the ice cover. The deepest part of the river reach is about 7 meters deep and the maximum thickness of frazil is about 3 meters. (Kymijoki winter 1987).

### 3.7 Appearance of ice cover

The appearance of ice cover was observed by aerial photographs and field observations along the riverside using photography and observation form no. 1. ( Appendix 1 ). Aerial photography proved to be the most efficient way to observe the appearance of ice cover. The results of aerial photography were drawn on maps (Figure 7). In Kalajoki the appearance of ice cover was digitized according to photography (Figure 8).

The appearance of ice cover was observed 3 – 5 times during freeze–up, 1 – 2 times during winter time and 3 – 5 times during break–up at every study reach.

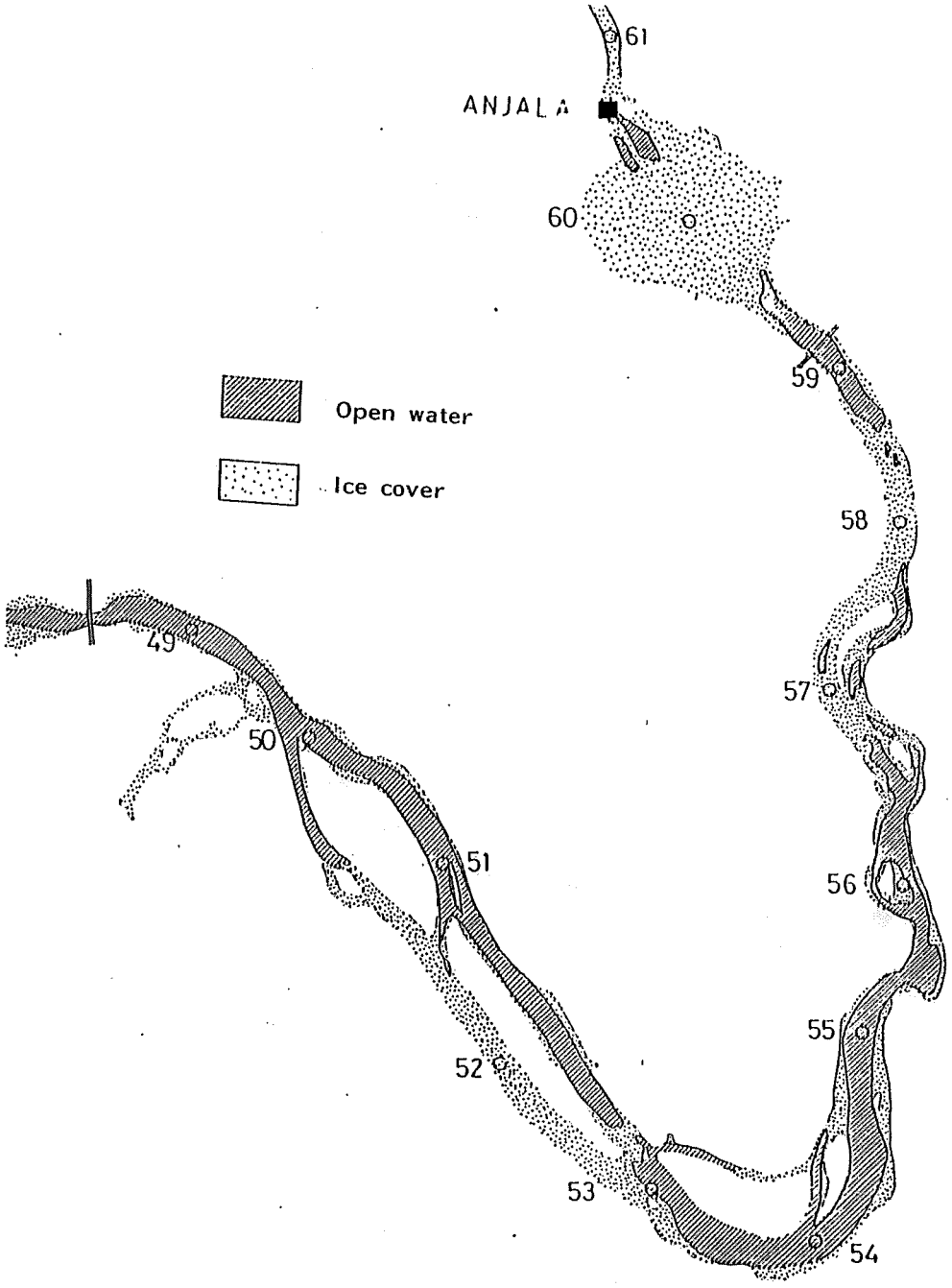


Figure 7. Example of the maps, which were drawn according to the information of aerial photography. The upper study reach of the river Kymijoki.

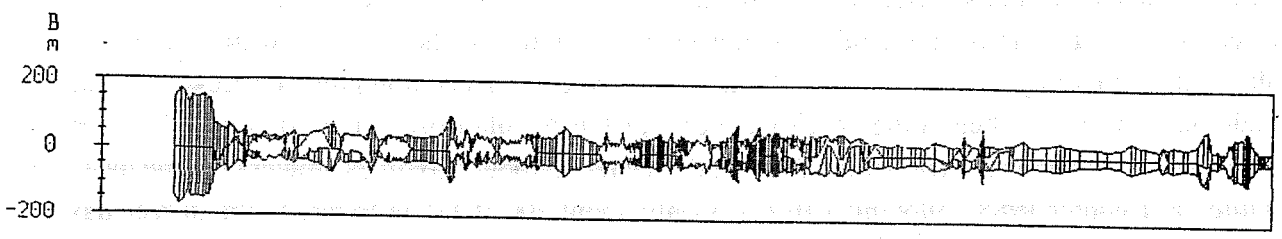


Figure 8. At Kalajoki the information of aerial photographs was digitized for every cross–section. The comparison between calculated and observed results can be made easily. However the information about river bends and other geometry is lost. ( Kalajoki 15.12. 1986.)

### 3.8 Strength of ice cover

Strength of the ice cover was measured in spring at Kalajoki by an experiment bending a beam. In the experiment three beams, the width of which was equal to the thickness of the ice cover, were sawed into the ice cover. The length of each beam was about 10 times of its width. The beam was pressed from the free floating and until it was broken. The strength needed to break the ice cover was measured.

# 4. ABOUT OBSERVATIONS

## 4.1 Weather conditions

The weather conditions differed quite strongly from the mean values during the river ice research project. Almost the coldest winter (1987) and almost the warmest winter (1989) in about one hundred years were observed during the project. The cumulative degree–day value (calculated from the beginning of November) at the Nivala observation station (the river Kalajoki) was 1600 °CD for winter 1986–1987, which is about 1.6 times greater than the mean value. For winter 1988–1989 this value was only about 700 °CD. In Figure 9 the degree day values at Nivala observation station for winters 1985–1989 are presented.

The fall 1986 was exceptionally rainy and discharges during the freeze–up were high. Common feature for all the years during the project was sunny and rainless springs. There were actually no break up ice dams in the observation rivers during the project.

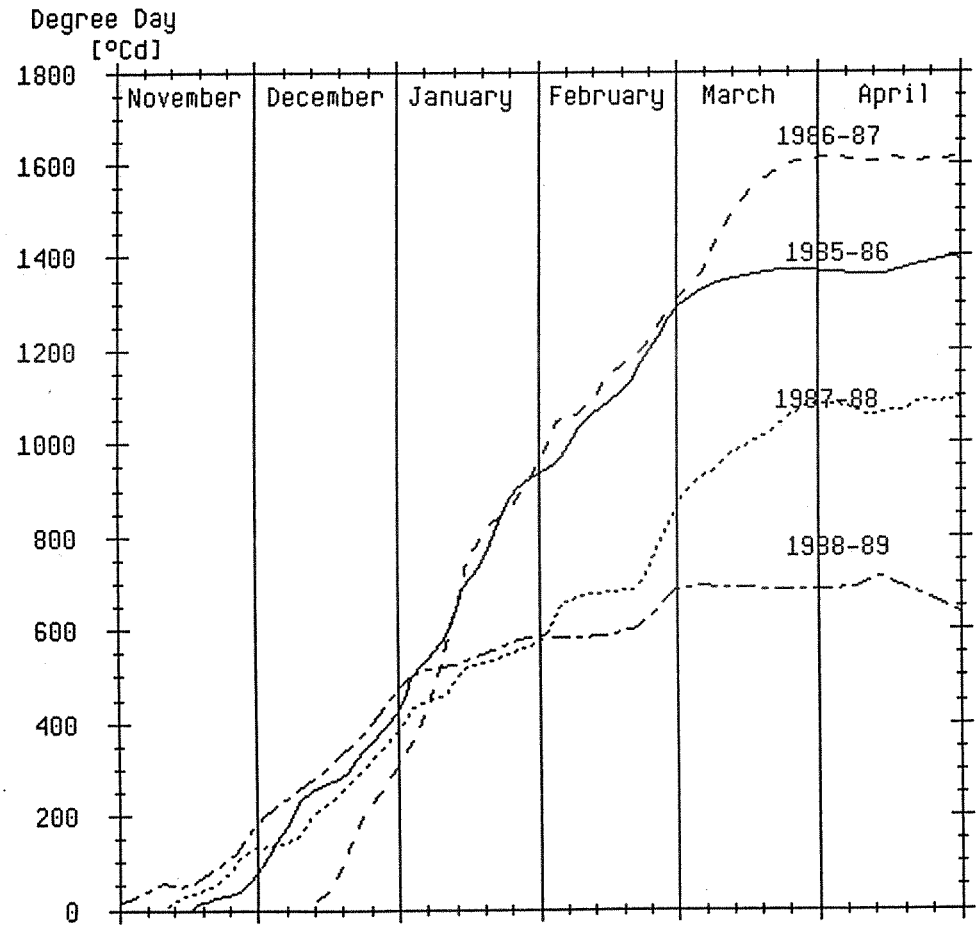


Figure 9. The degree day values at Nivala observation station for winters 1985–1989.

### 4.2 Freeze–up

Every winter the observations of the river ice research project began with the measuring of water temperature at the upstream end of the every study reach. Observed values were stored automatically excluding the observations at Kymijoki. The interval for the storing of automatically observed water temperature values was one hour and observations were started when water temperature reached + 1,0 °C. A lot of water temperature observations were made also manually during freeze–up time. Manual measurement of water temperature during freeze–up is often very difficult to arrange, because in small rivers water temperature drops very quickly to 0 °C.

Ice cover formation effects often very strongly to water levels in a river. The observed water level and calculated open water level for 3–8 December 1986 at Madekoski gauge in Oulujoki are presented in Figure 10. The rise in water level which is caused by forming ice cover is about 1,0 m.

The observation form 1 (Appendix 1) was used to gather freeze–up data.

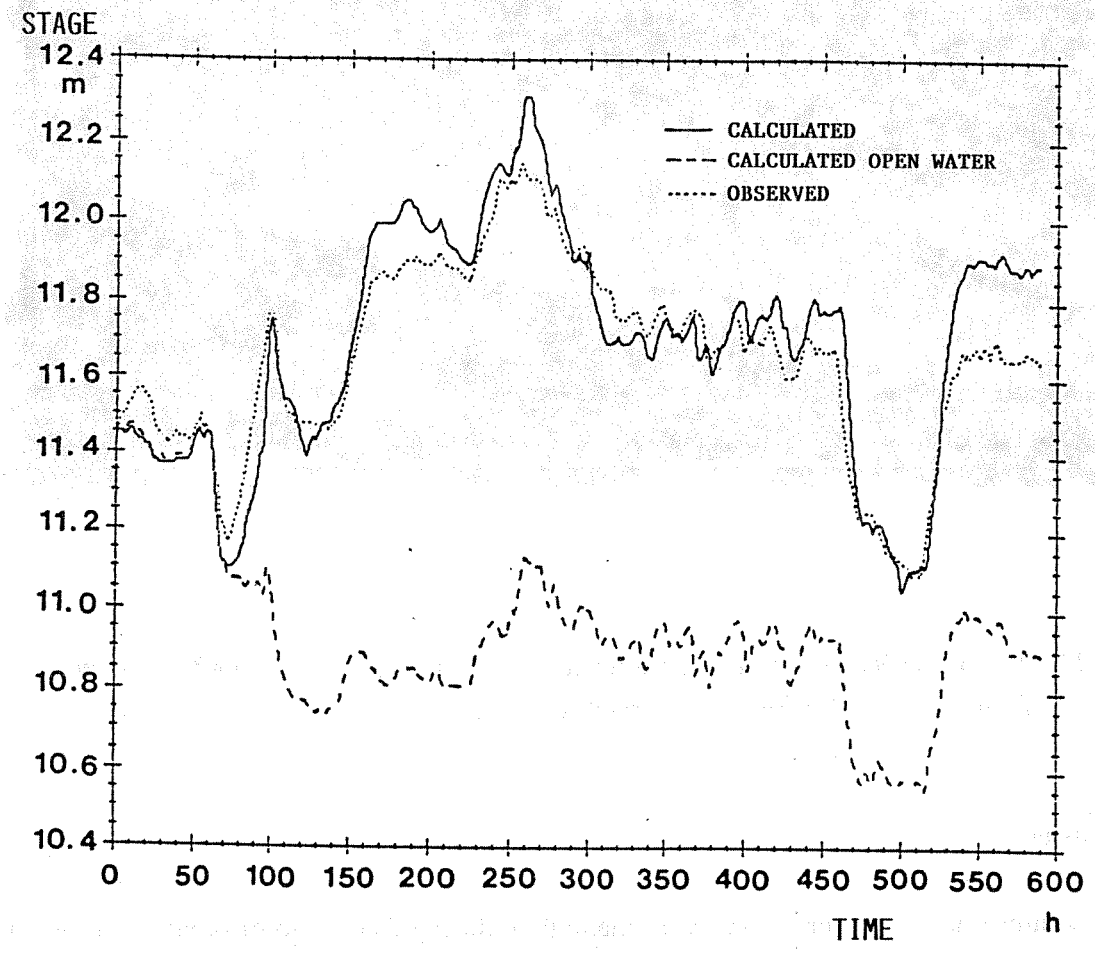


Figure 10. The observed water level and calculated open water level for 3–8 December 1986 at the Madekoski gauge in the River Oulujoki.

Aerial photography proved to be a very efficient way to gather data during freeze–up time. By using aerial photography the extent of ice cover could be observed with reasonable costs. From the aerial photographs also the way of ice cover forming and the border between statically and dynamically formed ice cover may be determined (Figure 11). Also the amount of moving skim ice can be estimated. Aerial photograhy was made 3 – 5 times during freeze–up time at every study reach. According to the information got from the photos, the appearance of ice cover was either drawn on maps (Kymijoki, Oulujoki and Kitinen) or digitized (Kalajoki).

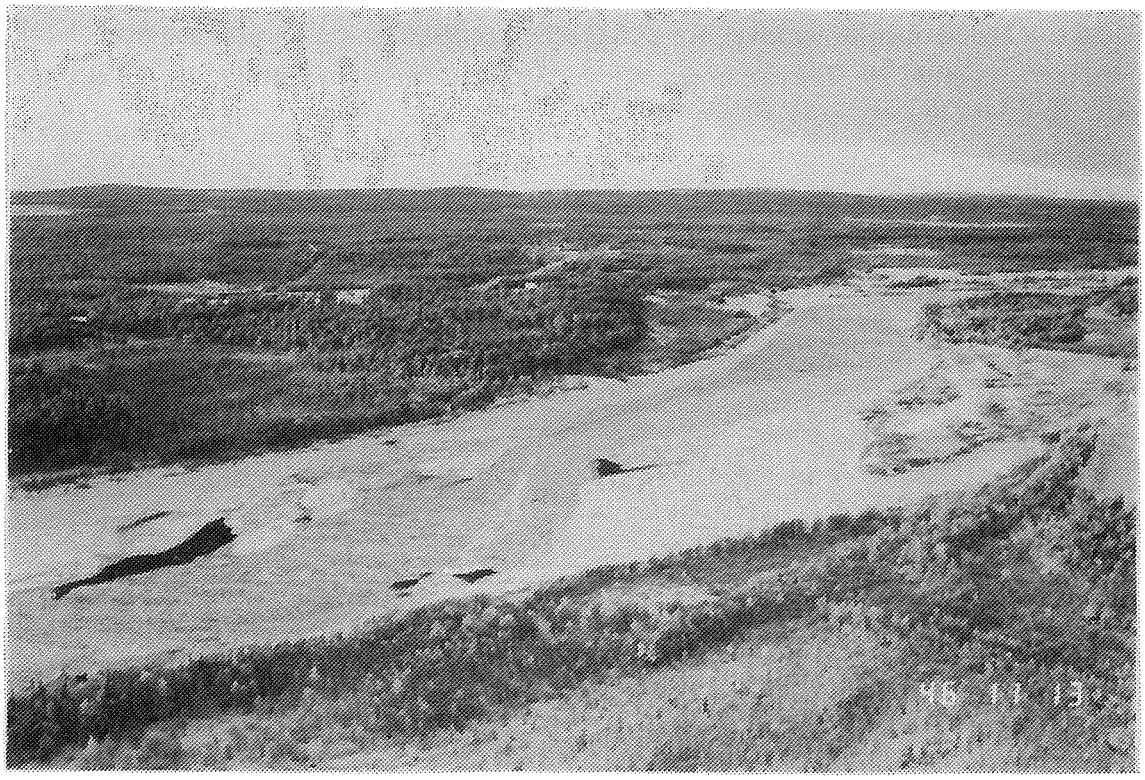

Figure 11. Part of the River Kitinen just after ice cover formation. The border between statically and dynamically formed ice cover can be determined

### 4.3 Winter

During wintertime less observations were made than during freeze–up or break–up time. The observers consentrated to gather data from the thermal growth of ice cover, but also some information about water level, water temperature and the extent of ice cover. Discharge values from the power plant are naturally available also during wintertime.

The information about the thickness of ice cover was gathered to observation form 2 (Appendix 2). The observations were made once a month during wintertime. During freeze–up and break–up ice cover thickness observations were made once a week. The ice cover (black ice and snow ice) thicknesses for Tilvis (Kalajoki) 1986 – 1989 are presented in Figure 12.

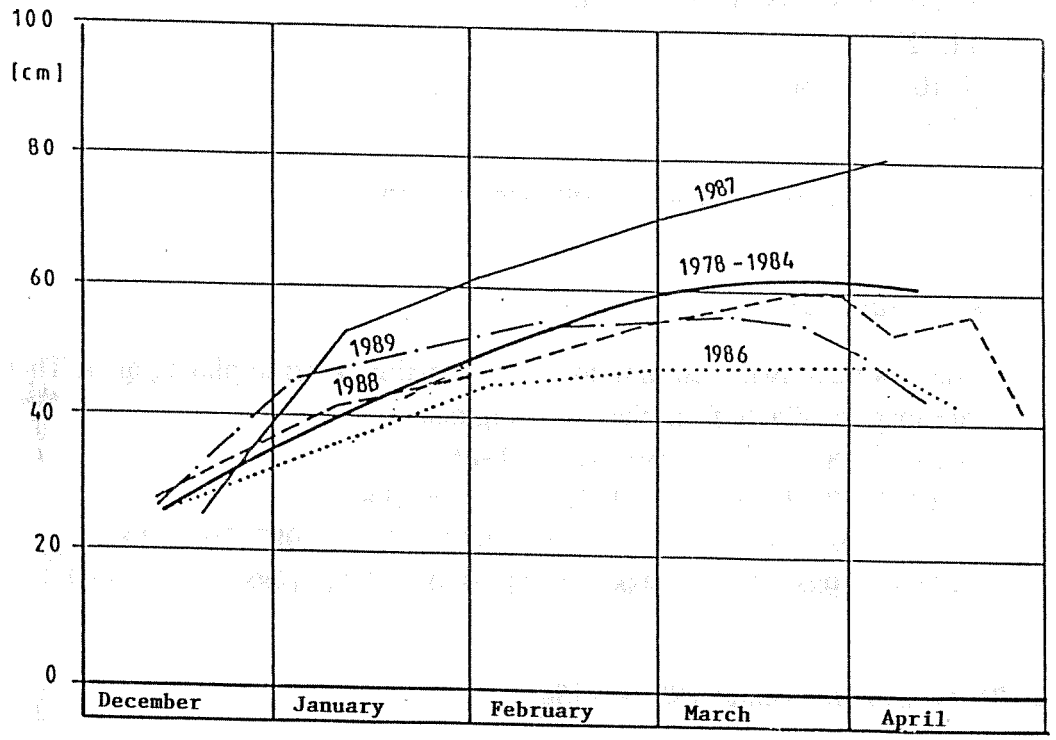


Figure 12. The ice cover (black ice and snow ice) thicknesses for Tilvis (the River Kalajoki) 1986 –1989.

### 4.4 Break–up

During break–up the observations were made more often. During this period, which was about one month, the observations about water level (manual gauges), water temperature (manual gauges) and ice cover thickness were made once per week. Aerial photography was made 3 –5 times. Because of rainless sunny springs there were actually no break–up ice dams.

# 5. OBSERVATIONS OF THE RIVER KYMIJOKI

## 5.1 The original observation data of the River Kymijoki

The original observation data of the River Kymijoki is stored by the Kymi District Office of the National Board of Waters and the Environment.

The Kymi District Office of the National
Board of Waters and the Environment
PL 23
45101 Kouvola
FINLAND

The original observation data is stored to the following folders:

*KYM 1 Ice coverage maps*

Maps were drawn according to the information of aerial photographs. There are maps available from the following dates:
– 1.12. 1985 , 15.12. 1986 , 18.12. 1986
– 2.1. 1987 , 16. 1. 1987 , 1. 3. 1987 , 4.4. 1987
– 7.12. 1987 , 8. 12. 1987 , 11. 12. 1987 , 16. 12. 1987, 30.1. 1988
– 21.11. 1988 , 23.11. 1988 , 28. 11. 1988 , 12.12. 1988 , 23. 1. 1989

*KYM 2 Photos from the winter 1985 – 1986*

*KYM 3 Photos from the winter 1985 – 1986*

*KYM 4 Photos from the winter 1986 – 1987*

*KYM 5 Photos from the winter 1986 – 1987*

*KYM 6 Photos from the winter 1987 – 1988*

*KYM 7 Photos from the winter 1987 – 1988*

*KYM 8 Photos from the winter 1988 – 1989*

## 5.2 The digitized observation data of the River Kymijoki

The digitized observation data of the River Kymijoki is divided into five files:

– KYMGEOM.DAT
–cross–sectional data

- KYMWEATH.DAT
  –weatherdata 1985–1988
- KYM_TW_W.DAT
  –manually observed stage values and water temperature values
- KYMICETH.DAT
- –ice cover and frazil thickness data
- KYMCONT.DAT
- –continuous observations about discharge, stage and water temperature

### 5.2.1 The cross–sectional data of the River Kymijoki

The cross–sectional data of the River Kymijoki is stored in file KYMGEOM.DAT in format FORMAT 1 . (Appendix 3).

### 5.2.2 The meteorological data of the River Kymijoki

The meteorological data for the River Kymijoki for the winters 1985–1986, 1986–1987 and 1987–1988 is from the Utti observation station. Data is stored in the file KYMWEATH.DAT in format FORMAT 2 (Appendix 4). In the file there is the following data at the interval of three hours:

–1.10.1985 – 31.5.1986
- –air temperature
- –air pressure
- –precipitation (6 hours interval)
- –wind speed
- –wind direction
- –cloudiness

–1.10.1986 – 31.5.1987 and 1.10.1987 – 31.5.1988
- –air temperature
- –air pressure
- –precipitation (6 hours interval)
- –wind speed
- –wind direction
- –cloudiness
- –relative humidity

### 5.2.3 Manually observed stage and water temperature data

Manually observed stage and water temperature data for the River Kymijoki is stored in the file KYM_TW_W.DAT in the format FORMAT 3 (Appendix 5). There is stage data available at the following sites:

–Kokonkoski cs 33.0
–Laajakoski upper cs 83.0 (85.0)
–Laajakoski ala cs 77.0
–Pernoo ylä cs 144.0

–Kultainkoski lower cs 373.0
–Ahvio lower cs 413.0
–Susikoski cs 486.0
–Kultainkoski upper cs 381.0
–Ahvio upper cs 435.0
–Anjalankoski lower cs 606.0

Water temperature data is available from the following sites:

–Kyminlinna bridge cs 26.0
–Pernoo bridge cs 119.0
–Anjalankoski cs 606.0
–Kokonkoski cs 33.0
–Susikoski cs 486.0

### 5.2.4 The ice thickness and frazil thickness data for the River Kymijoki

The ice thickness and frazil thickness data for the River Kymijoki is stored in the file KYMICETH.DAT in format FORMAT 4 (Appendix 6). The data is available from the following sites:

– downstream of the Ahvionkoski rapids ( 5 cross–sections)
– Downstream of the Kultainkoski rapids ( 3 cross–sections)
– Kyminlinna ( 3 cross–sections).

### 5.2.5 The continuous observations of the River Kymijoki

At the River Kymijoki continuous observations were made at the Anjalankoski power plant (discharge and stage) Susikoski, Ahvionkoski and Pernoonkoski (stage). The data is stored for the time interval 1.10.1985 – 31.12.1987 as daily mean values to the file KYMCONT.DAT in the following format (FORTRAN–77):

–FORMAT(2X, I4, I2, I2, F3.0, I2, F6.1, 5F6.2)
–at the beginning of each row is two empty columns
– I4 year
– I2 month
– I2 day
– F3.0 hour
– I2 minute
– F6.1 the discharge at the Anjalankoski (Kuusankoski) power plant
– F6.2 w The tail water (stage) at Anjalankoski power plant
– F6.2 w Susikoski cs 486.0
– F6.2 w Ahvio upper cs 435.0
– F6.2 w Pernoo upper cs 144
– F6.2 w Pernoo lower

# 6. OBSERVATIONS OF THE RIVER KALAJOKI

## 6.1 The original observation data of the River Kalajoki

The original observation data of the River Kalajoki is stored by the Kokkola District Office of the National Board of Waters and the Environment.

The Kokkola District Office of the National
Board of Waters and the Environment
Torikatu 40 B
SF–67100 Kokkola
FINLAND

The original observation data is stored to the following 16 folders:

*KAL 1 Ice cover thickness measurements 1985 – 1986*

*KAL 2 Observation forms 1985 – 1986*

*KAL 3 Observation forms 1986 – 1987*

*KAL 4 Stage and ice cover thickness data 1987 – 1988*

*KAL 5 Water temperature data 1987 – 1988 ja 1988 – 1989*

*KAL 6 Ice cover thickness measurements 1987 – 1988*

*KAL 7 Stage and discharge measurements at Hamari power plant 1987 – 1988*

*KAL 8 Ice cover thickness measurements 1988 – 1989*

*KAL 8 Data from automatical stage gauges at Isoranta and Alavieska 1986 –1989*

*KAL 9 Ice strength measurements*

*KAL 10 Observation reports*

*KAL 11 Photos from the winter 1985 – 1986*

*KAL 12 Photos from the winter 1985 – 1986*

*KAL 13 Photos from the winter 1986 – 1987*

*KAL 14 Photos from the winter 1986 – 1987*

*KAL 15 Photos from the winter 1987 – 1988*

*KAL 16 Photos from the winter 1987 – 1988*

### 6.2 The digitized observation data of the River Kalajoki

The digitized observation data of the River Kalajoki is divided into six files:

- KALGEOM.DAT
  –cross–sectional data
- KALWEATH.DAT
  –weatherdata 1985–1988
- KAL_TW_W.DAT
  –manually observed stage values and water temperature values
- KALICETH.DAT
  –ice cover and frazil thickness data
- KALCONT.DAT
  –continuous observations about discharge, stage and water temperature
- KALCOV.DAT
  –digitized information about ice coverage

#### 6.2.1 The cross–sectional data of the River Kalajoki

The cross–sectional data of the River Kalajoki is stored into the file KALGEOM.DAT in format FORMAT 1 . (Appendix 3).

#### 6.2.2 The meteorological data of the River Kalajoki

The meteorological data for the River Kalajoki for the winters 1985–1986, 1986–1987 and 1987–1988 is from the Nivala observation station. Data is stored into the file KALWEATH.DAT in format FORMAT 2 (Appendix 4). In the file there is the following data at the interval of four hours:

–1.10.1985 – 31.5.1986
- –air temperature
- –air pressure
- –precipitation
- –wind speed
- –wind direction
- –cloudiness

–1.10.1986 – 31.5.1987 and 1.10.1987 – 31.5.1988
- –air temperature
- –air pressure
- –precipitation
- –wind speed
- –wind direction
- –cloudiness
- –relative humidity

### 6.2.3 Manually observed stage and water temperature for the River Kalajoki

Manually observed stage and water temperature data for the River Kalajoki is stored into the file KAL_TW_W.DAT in the format FORMAT 3 (Appendix 8). There is stage data available at the following sites:

| | | | |
|---|---|---|---|
| 0.00 | 5.00 | 22.50 | 33.00 |
| 44.50 | 59.00 | 66.00 | 79.00 |
| 91.00 | 111.00 | 133.00 | 154.00 |
| 177.00 | 193.50 | 215.00 | 234.00 |
| 246.50 | 254.00 | 262.00 | 272.00 |
| 332.00 | 365.00 | 421.00 | 425.00 |
| 429.40 | 439.00 | 492.00 | 563.00 |
| 566.00 | 591.00 | | |

The observations were made:

- 11. – 12. 11. , 21. – 22. 11. , 9. – 10. 12. ja 30. – 31. 12. 1985
- 6. – 10. 2. , 20. – 24. 3. , 10. 4. , 5. – 6. 11. ja 22. – 23. 12 1986
- 16. 4. , 2. – 3. 11. , 16. – 18. 12. 1987
- 12.4. ja 6. 5. 1988

Manually observed water temperature is available from the following sites:

| | |
|---|---|
| –Kalajoki cs 10.00 | –Vääräjokisuu cs 91.00 |
| –Tynkä cs 109.00 | –Alavieska cs 256.00 |
| –Hamari cs 453.00 | –Padinki cs 605.00 |
| –Juntti–Kiekko cs 648.00 | –Kuoppasilta cs 725.50 |
| –Pidisjärvi cs 740.00 | |

### 6.2.4 The ice thickness and frazil thickness data for the River Kalajoki

The ice thickness and frazil thickness data for the River Kalajoki is stored into file KALICETH.DAT in format FORMAT 4 (Appendix 9). The data is available from the following sites (most of the cross–sections are measured 36 times during the project):

| | | |
|---|---|---|
| –20.00 | 0.00 | 92.00 |
| 98.00 | 102.00 | 142.00 |
| 240.00 | 246.00 | 250.00 |
| 254.00 | 260.00 | 272.00 |
| 381.00 | 439.00 | 580.00 |
| 492.00 | 572.00 | 795.50 |

### 6.2.5 The continuous observations of the River Kalajoki

At the River Kalajoki continuous observations were made at the Hamari and Padinki power plants (discharge, water temperature and stage) and at the automatical gauges Alavieska, Tilvis and Isoranta (stage). Also so the estimated discharge and measured water temperature for the tributary Vääräjoki is stored for some time intervals. The data is stored into the file KALCONT.DAT in the following format (FORTRAN–77):

–FORMAT(2X,I4,I2,I2,F3.0,I2,2(F6.1,F6.2,F6.2,F5.2),3F6.2,F5.1,F5.2)
at the beginning of each row is two empty columns

- I4 year
- I2 month
- I2 day
- F3.0 hour
- I2 minute
- F6.1 discharge at Hamari power plant
- F6.2 head water at Hamari
- F6.2 tail water Hamari
- F5.2 water temperature Hamari
- F6.1 discharge at Padinki power plant
- F6.2 head water Padinki
- F6.2 tail water Padinki
- F5.2 water temperature Padinki
- F6.2 stage at Alavieska
- F6.2 stage at Tilvis
- F6.2 stage at Isoranta
- F5.1 lateral inflow; Vääräjoki
- F5.2 temperature of the inflow: Vääräjoki

The discharge and stages at Hamari and Padinki are stored:

–as daily mean values:
- 1. 11. 1985 – 15. 5. 1986
- 11. 12. 1986 – 15. 5. 1987
- 16. 11. 1987 – 15. 5. 1988

–as hourly mean values:
- 28. 11. 1986 – 10. 12. 1986
- 1. 11. 1987 – 15. 11. 1987

Water temperature at Hamari and Padinki is stored:
- 1. 12. – 31. 12. 1986 (only Hamari)
- 8. 11. – 15.11. 1987
- 15. 4. – 3. 5. 1988

Stage at automatical gauges is stored as hourly mean values for 28. 11. – 10. 12. 1986 and as daily mean values for:

–Alavieska

– 21. 12. 1985 – 15. 5. 1986
– 11.12. 1986 – 6. 5. 1987
– 12. 12. 1987 – 15. 5. 1988

–Tilvis

– 1. 11. 1985 – 15. 5. 1986
– 11. 12. 1986 – 15. 5. 1987
– 16. 11. 1987 – 30. 4. 1988

–Isoranta

– 30. 12. 1985 – 21. 4. 1986
– 11. 12. 1986 – 20. 4. 1987
– 8. 12. 1987 – 30. 4. 1988

# 7. OBSERVATIONS OF THE RIVER OULUJOKI

## 7.1 The original observation data of the River Oulujoki

The original observation data of the River Oulujoki is stored by the Oulujoki Oy.

Oulujoki Oy
SF–91430 Leppiniemi
FINLAND

The original observation data is stored in the following 15 folders:

*OUL 1* *Observation forms and observation maps, freezing time 1985*

*OUL 2* *Continuos water temperature, water level and discharge, freezing time 1985*

*OUL 3* *Photos, freezing time 1985*

*OUL 4* *Observation forms and observation maps, winter and break–up 1986*

*OUL 5* *Continuos water temperature, water level and discharge, winter and break–up 1986*

*OUL 6* *Continuos water temperature, water level and discharge, winter and break–up 1986 (cont.)*

*OUL 7* *Observation forms and continuos water temperature, water level and discharge 1986–1987*

*OUL 8* *Additional information about summer stages and discharges*

*OUL 9* *Photos 1986 – 1987*

*OUL 10* *Continuos water temperature, water level and discharge, 1987 – 1988*

*OUL 11* *Aerial photographs 13. 11. 1987 and 16. 11. 1987*

*OUL 12* *Aerial photographs 18. 11. 1987 and 9. 12. 1987*

*OUL 13* *Continuos water temperature, water level and discharge, freezing time 1988*

*OUL 14* *Aerial photographs 1. 11., 3. 11. ja 7. 11. 1988*

*OUL 15* *Aerial photographs 8. 11., 14. 11., 21. 11., and 12. 12. 1988*

## 7.2 The digitized observation data of the River Oulujoki

The digitized observation data of the River Oulujoki is divided into six files:

- OULGEOM.DAT
  –cross–sectional data
- OULWEATH.DAT
  –weatherdata 1985–1988
- OUL_TW_W.DAT
  –manually observed stage values and water temperature values
- OULICETH.DAT
  –ice cover and frazil thickness data
- OULCONT.DAT
  –continuous observations about discharge, stage and water temperature.

### 7.2.1 The cross–sectional data of the River Oulujoki

The cross–sectional data of the River Oulujoki is stored in file OULGEOM.DAT in format FORMAT 1 . (Appendix 6)

### 7.2.2 The meteorological data of the River Oulujoki

The meteorological data for the River Oulujoki for the winters 1985–1986, 1986–1987 and 1987–1988 is from the Oulunsalo Airport observation station. Data is stored into the file OULWEATH.DAT in format FORMAT 2 (Appendix 7). In the file there is the following data at the interval of four hours:

–1.10.1985 – 31.5.1986
  –air temperature
  –air pressure
  –precipitation
  –wind speed
  –wind direction
  –cloudiness

1.10.1986 – 31.5.1987 and 1.10.1987 – 31.5.1988
  –air temperature
  –air pressure
  –precipitation
  –wind speed
  –wind direction
  –cloudiness
  –relative humidity

### 7.2.3 Manually observed stage and water temperature for the River Oulujoki

Manually observed stage and water temperature data for the River Oulujoki is stored into the file OUL_TW_W.DAT in the format FORMAT 3 (Appendix 8).

There is stage data available from the Laukka Bridge (cross–section 197). Water temperature data is available from the following sites:

| | |
|---|---|
| –Laukka Bridge (cs 192) | –Cross–section 145 |
| –Madekoski (cs 66) | –Heikkilän suvanto (cs 40) |
| –Water treatment plant(cs12) | –Merikoski power plant (cs 0) |

Information from 143 observation form was stored.

### 7.2.4 The ice thickness and frazil thickness data for the River Oulujoki

The ice thickness and frazil thickness data for the River Oulujoki is stored in file OULICETH.DAT in format FORMAT 4 (Appendix 9). The data is available from the following sites:

–cross–sections:

| | | | |
|---|---|---|---|
| 40 | 43 | 48 | 52 |
| 55 | 59 | 83 | 86 |
| 88 | 91 | 168 | 170 |
| 172 | 178 | 180 | 182. |

### 7.2.5 The continuous observations of the River Oulujoki

At the River Oulujoki continuous observations were made at the Montta and Merikoski power plants (discharge, water temperature and stage) and at the automatical gauges Juurusoja, Madekoski and Päivärinne (stage). The data is stored into file OULCONT.DAT at the interval of one hour for 8.11.1985 – 31.12.1985, 17.11.1986 – 31.12.1986 and 1.11.1987 – 1.1. 1988. The data is in the following format (FORTRAN–77):

FORMAT( I2, I4, I2, I2, F3.0, I2, F5.1, F6.2, F5.2, 3x, F5.1, F6.2, F5.2, 3(F6.2))

3198612 116.00633.0 13.45 .89 664.0 9.88 .86 13.00 11.56 11.06

| | | |
|---|---|---|
| I2 | 3 | Observation River (Oulujoki) |
| I4 | 1986 | year |
| I2 | 12 | month |
| I2 | 1 | day |
| F3.0 | 16. | hour |
| I2 | 00 | minute |
| F5.1 | 633.0 | discharge at the Montta power plant |

| | | |
|---|---|---|
| F6.2 | 13.45 | tailwater at the Montta power plant |
| F5.2 | 89 | water temperature at the Montta power plant |
| F5.1 | 664.0 | discharge at the Merikoski power plant |
| F6.2 | 9.88 | tailwater |
| F5.2 | .86 | water temparature |
| F6.2 | 13.00 | stage at the Päivärinne gauge |
| F6.23 | 11.56 | stage at the Madekoski gauge |
| f6.2 | 11.06 | stage at the Juurusoja gauge |

# 8. OBSERVATIONS OF THE RIVER KITINEN

## 8.1 The original observation data of the River Kitinen

The original observation data of the River Kitinen is stored by Kemijoki Ltd.

Kemijoki Ltd.
P.O.B. 28
SF–96101 Rovaniemi
FINLAND

The original observation data (written material in Finnish only) is stored in the following 18 folders:

*KIT 1 The freeze–up of 1985; a report*

*KIT 2 Stages, freezing time 1985*

*KIT 3 Water temperatures, ice cover thickness, freezing time 1985*

*KIT 4 Ice cover maps 14.11. , 20.11. ja 11.12. 1985.*

*KIT 5 Photos, Aerial photography 14.11. , 20.11. ja 11.12. 1985*

*KIT 6 Data for winter time 1985 – 1986*

*KIT 7 Winter time and break–up time 1986: a report*

*KIT 8 Data for break–up time 1986*

*KIT 9 Freeze–up time 1986: a report*

*KIT 10 Border ice formation downstream of Vajukoski power plant 1987*

*KIT 11 Freeze–up time 1986; data*

*KIT 12 Photos, freeze–up time 1986*

*KIT 13 Winter and break–up 1986 –1987: a report*

*KIT 14 Winter and break–up 1986 –1987: data*

*KIT 15 Ice cover maps. Aerial photographs, winter and break–up 1986 –1987*

*KIT 16 Winter 1987 – 1988, a report*

*KIT 17 Winter 1987 – 1988, data*

*KIT 18 Winter 1988 – 1989, a report*

## 8.2 The digitized observation data of the River Kitinen

The digitized observation data of the River Kitinen is divided into five files:

- KITGEOM.DAT
  –cross–sectional data
- KITWEATH.DAT
  –weatherdata 1985–1988
- KIT_TW_W.DAT
  –manually observed stage values and water temperature values
- KITICETH.DAT
  –ice cover and frazil thickness data
- KITCONT.DAT
  –continuous observations about discharge, stage and water temperature

### 8.2.1 The cross–sectional data of the River Kitinen

The cross–sectional data of the Rriver Kitinen is stored into file KITGEOM.DAT in format FORMAT 1 . (Appendix 6)

### 8.2.2 The meteorological data of the Rrver Kitinen

The meteorological data for the River Kitinen for the winters 1985–1986, 1986–1987 and 1987–1988 is from the Sodankylä (Ilmala) observation station. Data is stored into the file KITWEATH.DAT in format FORMAT 2 (Appendix 7). In the file there is the following data at the interval of four hours:

–1.10.1985 – 31.5.1986
  –air temperature
  –air pressure
  –precipitation
  –wind speed
  –wind direction
  –cloudiness

–1.10.1986 – 31.5.1987 and 1.10.1987 – 31.5.1988
  –air temperature
  –air pressure
  –precipitation
  –wind speed
  –wind direction
  –cloudiness
  –relative humidity.

### 8.2.3 Manually observed stage and water temperature for the River Kitinen

Manually observed stage and water temperature data for the River Kitinen is stored into the file KIT_TW_W.DAT in the format FORMAT 3 (Appendix 8). There is stage data available at the following sites:

–Tähtelä 72.0
–Sodankylä Bridge 78.00
–Kelukoski lower 82.00
–Kelukoski 82.50
–Kelukoski upper 83.50
–Sattanen 89.90
–Sakattioja 93.70
–Ruosteoja 96.80
–Kaarrekoski 99.00
–Risukkaoja 101.00
–Pietarinniva 106.50
–Matarasaari 109.00
–Alapostojoki 111.50
–Tailwater at the Vajukoski power plant 117.00

Water temperature observations were made at the following sites:

–Sodankylä Bridge 78.00
–Jeesiöjoen silta –1.00
–Sattasen silta –2.00
–Ala–postojoen silta –3.00
–Vajukoski power plant 117.00

There were totally 974 observation forms which have been digitized.

### 8.2.4 The ice thickness and frazil thickness data for the River Kitinen

The ice thickness and frazil thickness data for the River Kitinen is stored into file KITICETH.DAT in format FORMAT 4 (see. appendix 9). The data is available from the following sites:

Tähtelä 72.00
Kelukoski, ala 81.50
Kelukoski 82.00
Kelukoski 82.20
Kelukoski, ylä 83.50
Sakattioja 93.70

Hannunoja 104.00
Matarakoski 106.00
Pietarinniva 106.50
Pietarinniva 107.00
Pietarinniva 107.20
Ala–postojoki 111.50

### 8.2.5 The continuous observations of the River Kitinen

At the River Kitinen continuos observations were made at Tähtelä (discharge and stage), upstream of Kersilö bridge (stage), downstream of Matarasaari (stage) and at the Vajukoski power plant (discharge, stage and water temperature). The data is stored into the file KALCONT.DAT in the following format (FORTRAN–77):

FORMAT(I2, I2, I4, I2, I2, F3.0, I2, F6.2, F5.1, F5.2)

4 41985112012.00188.20 81.0 .05

| | | |
|---|---|---|
| I2 | 4 | River (Kitinen) |
| I2 | 4 | site (1=Tähtelä, 2=Kersilö, 3=Matarasaari, 4=Vajukoski) |
| I4 | 1985 | year |
| I2 | 11 | month |
| I2 | 20 | day |
| F3.0 | 12. | hour |
| I2 | 00 | minute |
| F6.2 | 188.20 | stage |
| F5.1 | 81.0 | discharge $m^3/s$ |
| F5.2 | .05 | water temperature |

The following data is available:

1. Tähtelä 72.00
   – 1.11. – 31.12. 1985
   –stage 6 values/day
   – 1.11.1986 – 22.5. 1987
   –stage 6 values/day

2. Upstream of Kersilö bridge
   – 14.11. 1986 – 25.5. 1987
   –stage 727 values

3. Matarasaari
   – 6.11. 1986 – 25.5. 1987

– stage 822

4. Vajukoski power plant
   – 1.11. 1985 – 30 12. 1985
     –discharge and stage (tailwater) once per hour
   – 1.11. 1986 – 23.5. 1987
     –discharge and stage (tailwater) once per hour
   – 2.11. 1987 – 9.5. 1988
     –discharge and stage (tailwater) once per hour

Water temperature was stored for freeze–up 1987.

## References

Huokuna, M. 1988. The Finnis River Ice Research Project. Proceedings of the 5th Workshop pn Hydraulics of River Ice/Ice Jams. Winnipeg. Manitoba, pp 15 – 42.

Huokuna, M. 1990. The Finnish River Ice Research Project – the Numerical River Ice Model in Use. IAHR Symposium on Ice, 1990 Helsinki. Proceedings Vol. 3, pp 215 –230.

# Appendix 1

1 (1)

## Observation form number 1

RIVER ICE RESEARCH PROJECT REITER Ltd. ICE OBSERVATION FORM 1

WATERSHED : _____ CODE : [ ][ ][ ][ ][ ]

RIVER : _____ CODE : [ ][ ][ ][ ][ ]

OBSERVATION STATION : _____ CODE : [ ][ ][ ][ ][ ]

RIVER KM _____

NAME OF THE OBSERVER : _____

DATE, TIME [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]
year month day h min

AIR TEMPERATURE + or - [ ][ ][ ].[ ][ ] °C

| | depth from water surface | | temperature + or - | |
|---|---|---|---|---|
| WATER TEMPERATURE | [ ][ ].[ ][ ][ ] | m | [ ][ ][ ].[ ][ ] | °C |
| | [ ][ ].[ ][ ][ ] | m | [ ][ ][ ].[ ][ ] | °C |
| | [ ][ ].[ ][ ][ ] | m | [ ][ ][ ].[ ][ ] | °C |

| | gauge code | 0-level | reading | |
|---|---|---|---|---|
| WATER LEVEL | [ ][ ][ ][ ][ ] | [ ][ ].[ ][ ] | [ ][ ].[ ][ ] | m |

IS THERE FRAZIL TO BE NOTICED
ON THE WATER SURFACE frazil slush (amount 0 - 5) [ ]

frazil pans (amount 0 -5 ) [ ]

( amount 0 = not at all, 5 = extreme amount)

ESTIMATED DIAMETER OF FRAZIL PANS [ ][ ] cm

HOW DO FRAZIL, FRAZIL PANS AND ICE FLOATS BEHAVE AT THE EDGE
OF A SOLID ICE-COVER

Accumulate at the upstream side (1)
get drawn under the ice-cover (2) [ ]

IS THERE water (1), snow (2), or both (3) on the ice-cover [ ]

PHOTOGRAPHS (1, if taken) [ ]

COMMENTS (1, if any) [ ]

_____

_____

_____

# Appendix 2

1 (1)

## Observation form number 2

RIVER ICE RESEARCH PROJECT REITER Ltd. ICE OBSERVATION FORM 2

WATERSHED : _____ CODE : [ ][ ][ ][ ][ ]

RIVER : _____ CODE : [ ][ ][ ][ ][ ]

OBSERVATION STATION : _____ CODE : [ ][ ][ ][ ][ ]

RIVER KM _____

NAME OF THE OBSERVER : _____

DATE, TIME [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]
year month day h min

LOCATION OF THE FIXPOINT IN VIEW OF THE FLOW left bank 1, right 2 [ ]

NUMBER OF THE OBSERVATION HOLES [ ][ ]

TOP WIDTH OF THE CROSS-SECTION [ ][ ][ ][ ] m

| NO. OF HOLES | DISTANCE FROM FIXPOINT | DEPTH OF SNOW | THICKNESS OF ICE /cm | | | DIFFERENCE BETWEEN SURFACE OF ICE AND WATER * | DEPTH OF WATER |
|---|---|---|---|---|---|---|---|
| | | | SNOW ICE | CLEAR ICE | FRAZIL OR SLUSH | | |
| 1 | m 2 | cm 3 | cm 4 | cm 5 | cm 6 | cm 7 | cm 8 |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

* positive, if water above ice surface, otherwise negative

COMMENTS (1=YES 0=NO) [ ]

FURTHER INFORMATION (general observations,more detailed information about sediment content etc.)

_____

_____

_____

_____

_____

_____

# Appendix 3

1 (2)

## Cross–sectional data

In this appendix the format for cross–sectional data is represented. The data for the four study reaches are stored in to the following files:

–KYMGEOM.DAT
–KALGEOM.DAT
–OULGEOM.DAT
–KITGEOM.DAT

Data is in free format in the following order:

***(1a) CS_KM(I), NUMBZY(I), ZLB(I), ZRB(I)***

*CS_KM(I) (Real)*
Cross–sections distance from the beginning of data (km)

*NUMBZY(I) (Real)*
The number of coordinate points in the cross–section.

*ZLB(I) (Real)*
Z–coordinate for the border between active and passive flow area in the left bank of the cross–section.

*ZRB(I) (Real)*
Z–coordinate for the border between active and passive flow area in the left bank of the cross–section.

***(1b) (Y(J,I), Z(J,I), J=1, NUMBZY(I))***

The y– and z–coordinates for the cross–section. Y–coordinate is the level of the coordinate point and z– coordinate is the distance of the coordinate point from the most left point. Coordinate points are arranged from left to right when we are looking downstream of the river.

# Appendix 3
2 (2)

## Example:

```
-0.400       6    0.00  117.00                          PL   1 / 355.000  116.
195.00     0.00  193.44   11.00  190.64   21.00  185.94   50.00  182.14    8
181.24   180.00  182.94  210.00  184.14  220.00  187.94  230.00  195.00   25
0.200       10    0.00  257.00                          PL   2 / 354.000  116.7
195.00     0.00  193.44   11.00  190.64   21.00  185.94   50.00  182.14    8
181.24   180.00  182.94  210.00  184.14  220.00  187.94  230.00  195.00   25
0.400        6    0.00  272.00                          PL   3 / 353.000  116.5
192.50     0.00  190.00   30.00  184.93   55.00  184.93  205.00  187.93   25
192.50   272.00
0.620        6    0.00  202.00                          PL   4 / 352.000  116.3
190.00     0.00  185.84   12.00  183.94   32.00  183.54  162.00  187.94   19
190.00   202.00
0.830        8    0.00  335.00                          PL   5 / 351.000  116.0
195.00     0.00  193.08   70.00  190.93   90.00  185.83  100.00  185.00   29
187.93   305.00  193.62  325.00  195.00  335.00
1.010        6    0.00  188.00                          PL   6 / 350.000  115.9
190.00     0.00  189.56   19.00  186.20   42.00  185.40  132.00  186.90   17
190.00   188.00
1.220        8    0.00  245.00                          PL   7 / 349.000  115.7
195.00     0.00  190.08   17.00  189.65   36.00  186.30   70.00  188.30    9
186.80   165.00  187.50  230.00  190.94  245.00
1.435        9    0.00  284.00                          PL   8 / 348.000  115.4
195.00     0.00  193.60    8.00  190.61   13.00  186.96   34.00  185.86    4
186.46   109.00  187.06  184.00  191.21  209.00  195.00  284.00
1.630        5    0.00  162.00                          PL   9 / 347.000  115.2
190.00     0.00  187.85    8.00  185.95   30.00  186.55  150.00  190.00   16
1.830        8    0.00  190.00                          PL  10 / 346.000  115.0
191.00     0.00  189.35   25.00  187.88   35.00  187.08   45.00  185.88   12
187.88   155.00  190.50  165.00  192.90  190.00
```

# Appendix 4

1 (2)

**Weather data**

In this appendix the format for weather data is represented. The data for the four study reaches is stored in to the following files:

–KYMWEATH.DAT
–KALWEATH.DAT
–OULWEATH.DAT
–KITWEATH.DAT

Data is in the following format (FORMAT 2)

–1.10.1985 – 31.5.1986

FORMAT(I4, 4(1X, I2), 1X, I6, I5, I5, I2, I3, I3)

–I4 Number of the observation station
–I2 Year
–I2 Month
–I2 Day
–I2 Hour
–I6 Air pressure 0,1 mbar
–I5 Air temperature 0,1 °C
–I5 Precipitation 0,1 mm
–I2 Cloudiness 0 . . . 8
–I3 Wind direction 10°
–I3 Wind speed $m^3/s$

–1.10.1986 – 31.5.1987, 1.10.1987 – 31.5.1988 and 1.10. – 31.12. 1988

FORMAT(I4, 4(1X, I2), 1X, I6, I5, I5, I2, I3, I3 I3)

–I4 Number of the observation station
–I2 Year
–I2 Month
–I2 Day
–I2 Hour
–I6 Air pressure 0,1 mbar
–I5 Air temperature 0,1 °C
–I5 Precipitation 0,1 mm
–I2 Cloudiness 0 . . . 8
–I3 Wind direction 10°
–I3 Wind speed $m^3/s$
–I3 Relative humidity %

# Appendix 4
2 (2)

**Example:**

```
5401 88 12 01 00 10112 -250 9999 1 00 00 85
5401 88 12 01 03 10110 -206 9999 9 15 01 87
5401 88 12 01 06 10101 -191    0 7 15 01 89
5401 88 12 01 09 10087 -150 9999 7 19 01 90
5401 88 12 01 12 10068 -080 9999 7 23 02 97
5401 88 12 01 15 10054 -085 9999 7 23 01 97
5401 88 12 01 18 10058 -070   -1 6 24 02 97
5401 88 12 01 21 10063 -070 9999 3 28 02 96
5401 88 12 02 00 10072 -068 9999 2 30 01 97
5401 88 12 02 03 10079 -073 9999 5 29 01 96
5401 88 12 02 06 10079 -090   -1 5 22 02 97
5401 88 12 02 09 10090 -084 9999 6 15 01 97
5401 88 12 02 12 10090 -078 9999 7 15 01 96
5401 88 12 02 15 10105 -087 9999 7 16 01 96
5401 88 12 02 18 10114 -080   -1 5 17 01 96
5401 88 12 02 21 10122 -100 9999 3 16 02 96
5401 88 12 03 00 10130 -055 9999 2 21 02 97
5401 88 12 03 03 10134 -046 9999 8 22 02 98
5401 88 12 03 06 10140 -020   -1 8 22 02 99
5401 88 12 03 09 10152 -014 9999 8 22 03 99
5401 88 12 03 12 10160 -024 9999 8 22 03 99
5401 88 12 03 15 10165 -014 9999 8 23 03 99
5401 88 12 03 18 10161 -016   -1 8 21 04 99
5401 88 12 03 21 10160 -042 9999 2 21 05 97
5401 88 12 04 00 10154 -040 9999 2 22 07 94
5401 88 12 04 03 10148 -030 9999 7 20 05 88
5401 88 12 04 06 10143 -053   -1 8 17 05 92
5401 88 12 04 09 10142 -060 9999 7 17 05 89
5401 88 12 04 12 10130 -088 9999 5 15 06 89
5401 88 12 04 15 10113 -110 9999 1 15 05 89
5401 88 12 04 18 10093 -120   -1 0 14 05 86
5401 88 12 04 21 10066 -116 9999 0 14 06 88
5401 88 12 05 00 10041 -095 9999 7 13 06 88
5401 88 12 05 03 10008 -073 9999 8 13 06 93
5401 88 12 05 06  9991 -066   17 8 14 05 93
5401 88 12 05 09  9983 -060 9999 7 10 05 93
5401 88 12 05 12  9972 -062 9999 8 14 04 90
5401 88 12 05 15  9960 -063 9999 8 14 03 92
5401 88 12 05 18  9954 -060   13 8 11 02 90
5401 88 12 05 21  9944 -053 9999 8 10 02 93
5401 88 12 06 00  9941 -062 9999 8 12 03 92
5401 88 12 06 03  9943 -064 9999 8 09 02 92
5401 88 12 06 06  9944 -065    8 8 08 02 91
5401 88 12 06 09  9957 -063 9999 8 07 02 92
5401 88 12 06 12  9961 -060 9999 8 06 02 95
5401 88 12 06 15  9970 -062 9999 8 05 01 96
5401 88 12 06 18  9989 -062   32 8 03 01 97
5401 88 12 06 21 10001 -062 9999 8 01 02 96
```

# Appendix 5

1 (2)

## The manually observed water temperature and water level data

In this appendix the **FORMAT 3** (format according to fortran–77) for manually observed water temperature and water level data is represented. The data for the four study reaches are stored into the following files:

–KYM_TW_W.DAT
–KAL_TW_W.DAT
–OUL_TW_W.DAT
–KIT_TW_W.DAT

FORMAT( I3, F7.2, 1x, I4, 4(I2), 1x, F5.1, 3(F4.1, F5.2), 2x, I4, 2(F6.2), 1x, 2(I1), I2, 4(I1) )

| | |
|---|---|
| I3 | The code for the river (1=Kymijoki, 2=Kalajoki, 3=Oulujoki, 4=Kitinen) |
| F7.2 | Code for the cross–section (normalli distance along the river) |
| 1X | |
| I4 | Observation year |
| I2 | month |
| I2 | day |
| I2 | hour |
| I2 | minutet |
| 1x | |
| F5.1 | Air temperature |
| F4.1 | Obrservation depth (1. depth) |
| F5.2 | Water temperature (at the 1. depth) |
| F4.1 | Obrservation depth (2. depth) |
| F5.2 | Water temperature (at the 2. depth) |
| F4.1 | Obrservation depth (3. depth) |
| F5.2 | Water temperature (at the 3. depth) |
| 2x | |
| I4 | Code for the water level gauge |
| F6.2 | 0–level for the water level gauge |
| F6.2 | Water level |
| 1x | |
| I1 | The amount of moving frazil at on the water surface 0 – 5 ( 0 = not at all , 5 = great amount) |
| I1 | The amount of frazil pans on the water surface 0 – 5 ( 0 = not at all , 5 = great amount) |
| I2 | The estimated diameter of frazil pans (cm) |
| I1 | How do frazil, frazil pans and ice floats behave at the edge of solid ice cover Accumulate at the upstream side (1) get drawn under the ice cover (2) |
| I1 | Is there water (1), snow or both (2) on the ice cover |
| I1 | Photographs ( 1, if taken) |
| I1 | Other comments 1 (if any) |

# Appendix 5

2 (2)

**Example:**

```
2 591.00 1986 418 845    .0  .5  .161.5  .17 .0  .00     0  .00   .00 00
2 616.50 1986 418 820    .0 2.0  .481.0  .48 .0  .00     0  .00   .00 00
2 617.00 1986 418 830    .0 1.0  .493.0  .50 .0  .00     0  .00   .00 00
2 724.00 1986 418 750  -2.5 1.0  .232.0  .23 .0  .00     0  .00 68.24 00
2 247.00 1986 4221040    .0 1.0  .031.0  .031.0  .03     0  .00   .00 00
2  91.00 1986 4211410    .0  .9  .07 .0  .00 .0  .00     0  .00   .00 00
2 100.00 1986 4211440    .0 2.0  .062.0  .061.5  .07     0  .00   .00 00
2  12.50 1986 4211340    .0  .4  .03 .4  .03 .0  .00     0  .00   .00 00
2 617.00 1986 422 8 0    .0 2.0  .352.0  .364.0  .36     0  .00   .00 00
2 591.00 1986 422 820    .0 1.5  .35 .0  .00 .0  .00     0  .00   .00 00
2 453.00 1986 422 940    .0 2.0  .063.0  .051.0  .05     0  .00   .00 00
2 724.00 1986 422 730    .0 2.0  .171.5  .17 .0  .00     0  .00 68.19 00
2 617.00 1986 424 830    .0 3.0  .422.0  .42 .0  .00     0  .00   .00 00
2 591.00 1986 424 9 0    .0 1.0  .421.0  .50 .5  .47     0  .00   .00 00
2 453.00 1986 42410 5    .0 2.5  .072.5  .08 .0  .00     0  .00   .00 00
2 247.00 1986 4241040    .0 1.0  .031.0  .08 .9  .06     0  .00   .00 00
2 100.00 1986 4241210    .0 1.5  .042.0  .032.5  .02     0  .00   .00 00
2  91.00 1986 4241250    .0 1.0  .02 .0  .00 .0  .00     0  .00   .00 00
2 724.00 1986 424 750    .0 2.0  .201.5  .24 .0  .00     0  .00   .00 00
2 617.00 1986 4251425    .0 2.0  .692.0  .68 .0  .00     0  .00   .00 00
2 591.00 1986 4251410    .0 1.0  .501.5  .101.5  .67     0  .00   .00 00
2 453.00 1986 4251325    .0 2.0  .052.0  .04 .0  .00     0  .00   .00 00
2 256.00 1986 42513 0    .0  .5  .07 .8  .06 .0  .00     0  .00   .00 00
2 109.00 1986 4251210    .0 1.0  .03 .8  .02 .7  .02     0  .00   .00 00
2  91.00 1986 4251150    .0 1.0  .08 .0  .00 .0  .00     0  .00  2.12 00
2  12.50 1986 4251120   6.9  .3  .08 .2  .031.5  .03     0  .00  2.12 00
2 724.00 1986 4251450    .0 1.5  .422.0  .371.5  .41     0  .00   .00 00
2 617.00 1986 427 8 5    .0 1.0  .102.5  .10 .0  .00     0  .00   .00 00
2 616.50 1986 427 8 0    .0 1.0  .093.0  .095.0  .09     0  .00   .00 00
2 591.00 1986 427 820    .0 1.5  .19 .5  .131.5  .13     0  .00   .00 00
```

# Appendix 6

1 (2)

## Ice cover thickness data

In this appendix the **FORMAT 4** (format according to fortran–77) for ice cover thickness data . The data for the four study reaches are stored into the following files:

–KYMICETH.DAT
–KALICETH.DAT
–OULICETH.DAT
–KITICETH.DAT

A FORMAT( I3, F7.2, 1x, I4, 4(I2), 1x, F5.1, 3(F4.1, F5.2), 2x, I4, 2(F6.2), 1x, 2(I1), I2, 5(I1), I2, I4, I1)

| | |
|---|---|
| I3 | The code for the river (1=Kymijoki, 2=Kalajoki, 3=Oulujoki, 4=Kitinen) |
| F7.2 | Code for the cross–section (normalli distance along the river) |
| 1X | |
| I4 | Observation year |
| I2 | month |
| I2 | day |
| I2 | hour |
| I2 | minutet |
| 1x | |
| F5.1 | Air temperature |
| F4.1 | Obrservation depth (1. depth) |
| F5.2 | Water temperature (at the 1. depth) |
| F4.1 | Obrservation depth (2. depth) |
| F5.2 | Water temperature (at the 2. depth) |
| F4.1 | Obrservation depth (3. depth) |
| F5.2 | Water temperature (at the 3. depth) |
| 2x | |
| I4 | Code for the water level gauge |
| F6.2 | 0–level for the water level gauge |
| F6.2 | Water level |
| 1x | |
| I1 | The amount of moving frazil at on the water surface 0 – 5 ( 0 = not at all , 5 = great amount) |
| I1 | The amount of frazil pans on the water surface 0 – 5 ( 0 = not at all , 5 = great amount) |
| I2 | The estimated diameter of frazil pans (cm) |
| I1 | How do frazil, frazil pans and ice floats behave at the edge of solid ice cover Accumulate at the upstream side (1) get drawn under the ice cover (2) |
| I1 | Is there water (1), snow or both (2) on the ice cover |
| I1 | Photographs ( 1, if taken) |
| I1 | The location of the 0–point for the ice cover thickness measurement (left bank 1, right bank 2) |

# Appendix 6



| | |
|---|---|
| I2 | The amount of observation holes |
| I4 | The depth of the river |
| I1 | Other comments 1 (if any) |

**B** FORMAT(I2, 7(I5)

| | |
|---|---|
| I2 | The number of the observation hole |
| I5 | The distance of the observation hole from the 0–point |
| I5 | Thickness of snow cover (cm) |
| I5 | Thickness of snow ice (cm) |
| I5 | Thickness of black ice (cm) |
| I5 | Thickness of frazil accumulation (cm) |
| I5 | Difference between surface of ice and water (positive, if water is above ice surface, otherwise negative |
| I5 | The depth of the river (cm) |

## Example:

```
2 -20.00 1986 2 31020     .0   .0   .00 .0   .00 .0   .00      0   .00    .00 00
1     0   19   21   33     0    0  210
2     0   21    6   42     0    3  170
3     0   11   15   46     0    5  195
2    .00 1986 2 31120     .0   .0   .00 .0   .00 .0   .00      0   .00    .00 00
1     0   11   38   36     0   18   72
2     0   10   23   45     0   10   95
3     0   15   18   46     0    1  130
4     0   34    2   52     0    0  260
5     0   13   30   37     0    4  170
2  92.00 1986 2 312 0     .0   .0   .00 .0   .00 .0   .00      0   .00    .00 00
1     0   23   25   23     0    1  130
2     0   20   20   24     0    0  260
3     0   22   18   22     0    0  230
4     0   15   35   20     0    0  110
2  98.00 1986 2 313 0     .0   .0   .00 .0   .00 .0   .00      0   .00    .00 00
1     0   21   35   26     0    2  120
2     0   25   13   28     0    0  320
3     0   22   13   29     0    0  345
4     0   20   22   40     0    0  250
2 102.00 1986 2 31230     .0   .0   .00 .0   .00 .0   .00      0   .00    .00 00
1     0   41   15   25     0   10  100
2     0   41   27   18    60   10  110
3     0   39   17   48    80   17    0
4     0   28   25   40     0    5  120
2 142.00 1986 2 41420     .0   .0   .00 .0   .00 .0   .00      0   .00    .00 00
1     0   41   13   36     0    1   60
2     0   26   19   19     0    0  300
3     0   29   16   23     0    0  310
4     0   27   15   24     0    0  300
5     0   23   27   21     0    2  220
2 240.00 1986 2 31430     .0   .0   .00 .0   .00 .0   .00      0   .00    .00 00
1     0   25   20   15     0    4   60
2     0   18    9   41     0    3  110
3     0   20   23   25     0    3  100
4     0   12   27   28     0    3  105
2 246.00 1986 2 31530     .0   .0   .00 .0   .00 .0   .00      0   .00    .00 00
1     0   20   18   29     0    7   70
2     0   24   17   25     0    1  130
3     0   25   11   30     0    0   65
4     0   20   27   24     0    1  165
```

# Appendix 7

1 (1)

**The digitized data of the amount of ice cover in the River Kalajoki. Data is digitized according to arerial photographs.**